# EUV-Residual Gas Exposure of Mo/Si Mirrors

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## INTRODUCTION

The Engineering Test Stand (ETS) is an advanced, prototypical lithography tool being developed in the EUVL (Extreme Ultraviolet Lithography) Program. In the ETS multilayer mirror (MLM) surfaces must be kept as clean as possible during tool operation in order to maximize mirror reflectivities and wafer throughput. In the presence of EUV radiation, the surface and near-surface regions of MLMs could be altered by EUV-photon induced chemistry between the mirror surfaces and residual gases present in the ETS vacuum. During 1999 we continued EUV-residual gas experiments started in 1998 with a primary goal of developing strategies for minimizing mirror degradation caused by water vapor exposure and maintaining original MLM reflectivities. This abstract outlines the work that was done.

## EXPERIMENTAL SYSTEMS

All experimental runs were performed using two different demountable, ultrahigh vacuum (UHV) chambers that could be attached to a port on the existing EUV Interferometry chamber on Beamline 12.0.1.2. The first chamber chamber was used for water vapor/carbon-containing gas (“Blend”) experiments described below. This chamber had a movable aperture located at the EUV beam crossover point downstream from the Interferometry chamber. This aperture provided vacuum isolation from the upstream beamline and permitted simultaneous EUV-gas exposure of ETS components. This chamber was described in more detail in our previous ALS Compendium Abstract[1]. A second UHV chamber had no aperture, and allowed samples to be placed within a few millimeters of the EUV crossover point. This chamber arrangement resulted in high photon fluxes to the sample and was used in the “Higher Power ” experiments described below.

## EXPERIMENTS

### I. “Blend” experiments

The goal of these experiments was to help determine if EUV-promoted oxidation of MLMs, which had been observed in our previous experiments in 1998, could be mitigated by coexposure with a carbon-containing gas. Three experimental runs were devoted to determining the effects of exposing Mo/Si multilayer mirrors (40 bilayer pairs, Si capping layer, maximum initial peak reflectivity of ~67.8% at 92.24 eV) to water and isobutane or ethyl alcohol(ETOH), either singly or together in the presence of EUV radiation. One experimental run examined the water/isobutane pair, two runs, the water/ETOH pair. Exposure pressures up to ~ $10^{-5}$ Torr and nominal beam powers of 10 $mW/mm^2$ at 92.3 eV (~1% bandwidth) were used. The change in multilayer mirror reflectivity was measured *in-situ* with the photodiode and *ex-situ* sputter-through Auger Electron Spectroscopy (AES) was used to help determine the change in the near surface composition of the mirrors. Little carbon deposition was detected when either isobutane or ETOH alone was used as the exposure gas. It was found that ETOH helped to stop oxidation of the MLMs when used in a proper ratio of partial pressures of ETOH/ water vapor. This result is being used as the basis for one means of controlling MLM oxidation in ETS.

## II. Higher Power Experiments

Higher power experiments were made with MLM samples exposed to EUV powers between ~ 0.025 $W/mm^2$ to ~1 $W/mm^2$ while directly coupled to the residual gas atmosphere of the M7 mirror chamber. Similar conditions were used in a previous study by Ziegler[2] , who measured carbon deposition rates as high as ~ 50 nm/hr at the higher photon fluxes. The goal of the current experiments were (1) to try to duplicate high carbon deposition rates seen by Ziegler, and (2) to see if there was any correlation between these rates and residual gas spectra and total electron photoyield currents from the mirrors during the extended exposures. In our present work, *in-situ* RGA scans taken during the exposures showed no evidence of high molecular weight hydrocarbons at mass/charge rations greater than about 44. Correspondingly, Auger sputter-through analyses performed on our samples indicated that the C deposition rates were significantly lower than those observed by Ziegler. It is possible that the M7 chamber was more contaminated with higher levels of carbon-containing species at the time that his measurements were taken. However, no RGA spectra were taken during the exposures in his work. The photoyield data obtained in our work were consistent with the formation of both carbonaceous and oxide layers on the MLM samples.

## SUMMARY

Applied EUV exposure experiments for the EUVL Program were performed on Beamline 12.0.1.2. These experiments have provided data essential for the planning and refinement of protection techniques for optical components in ETS.

## ACKNOWLEDGMENTS

Thanks especially to Ken Goldberg, Patrick Naulleau and Paul Denham for their help in interfacing our experiment to their EUV Interferometry System and providing critical assistance in making Beamline 12.0.1.2 work. We are also indebted to other CXRO personnel including, but not limited to, Phil Batson, Frank Zucca, and Kevin Bradley and his machine shop personnel. The Mo/Si multilayer mirrors used in all experiments were made by Paul Mirkarimi, LLNL.

## REFERENCES

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This work, performed at Sandia National Laboratories and at the Advanced Light Source, Lawrence Berkeley National Laboratories, was supported by the Extreme Ultraviolet Limited Liability Company (EUV LLC) and by the U. S. Department of Energy under contract DE-AC04-94AL85000.

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